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ANTARCTIC RESEARCH, GEOPHYSICAL MONOGRAPH NO. 7, 1962

The Geology of Antarctica

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Abstract—Over much of Antarctica rock exposures are very limited in extent, occurring mainly as isolated mountain ranges, nunataks, ice-free fringing coastal areas, and offshore islands, but the geological record is rich and most revealing.

The geological history of Antarctica has been a long and interesting one and in the course of geological time this continent has suffered the vicissitudes of mountain building processes, severe denudation and sedimentation in geosynclinal troughs, subsidence and incursions of the sea, large-scale crumpling and fracturing of its sedimentary cover, and the inundation of vast areas by lava flows and showers of volcanic ashes. From an interpretation of the fossil fauna and flora it is clear that the climate of Antarctica has undergone several reversals. In Permo-Carboniferous times glacial conditions prevailed, but in the Middle Jurassic the climate was temperate to sub-tropical, supporting a luxuriant flora. Since that time the climate has slowly deteriorated to a final refrigeration in the Pleistocene and Recent. Even during the present glaciation there have been several phases of advance and retreat.

Although the main continental shield of Antarctica is analogous to those of the other southern continents, comprising rocks which have undergone at least three phases of regional metamorphism, it is now clear that the continent is composed of two totally distinct and contrasting geological provinces, each of which has evolved separately under different environmental and tectonic conditions since early Paleozoic times.

East Antarctica, the older part of the continent, is the true Antarctic continental shield, on which rest relatively undisturbed early Paleozoic marine sediments and late Paleozoic-early Mesozoic terrestrial sediments of the widespread southern Gondwana System. The latter succession is heavily intruded by thick, often differentiated, dolerite sheets of Lower Jurassic age. The main tectonic disturbances in East Antarctica appear to be block faulting of a late Tertiary-Quaternary age, with which volcanism is widely associated. Many stratigraphic comparisons can be made with the other southern continents, especially southern Africa.

West Antarctica, including the Antarctic Peninsula, is stratigraphically, structurally and tectonically closely akin to the west Patagonian Cordillera, and is indeed a southern extension of the Andean Mountain chain via the Scotia Arc. In comparison with East Antarctica it is much younger in age, having evolved mainly as a result of uparching of the Andean geosynclinal sediments in the late Paleozoic. Widespread lava and ash eruptions in the Upper Jurassic, marginal to the Andean geosyncline, were associated with a period of minor folding. This was followed by further sedimentation and the formation of the mid- to late Cretaceous Magellan geosyncline and the large-scale intrusions of late Cretaceous-early Tertiary times. Further sedimentation was abruptly terminated by mid-Miocene volcanism which has continued intermittently until Recent times. Both block faulting and folding have played an important role in the formation of West Antarctica.

On the basis of stratigraphical, petrological, structural and paleogeographical studies, it is evident that Antarctica comprises two main geological provinces, for which the names 'Andean Province' (West Antarctica) and 'Gondwana Province' (East Antarctica) are proposed.

551:(*7)

Introduction—Geologically, the least-known of all the continents is undoubtedly Antarctica. Almost 95 pct of its area of approximately 5½ million sq mi is blanketed by the Antarctic Ice Sheet, and the best-exposed parts of the continent are the coastal regions of the Antarctic Peninsula, the marginal regions of East Antarctica, the high ranges of the coastal hinterland of South Victoria Land, and the isolated mountains and nunataks of the interior which pierce the ice carapace.

With the exception of the work in the Ant-

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arctic Peninsula sector of West Antarctica, the only geological exploration that had been done in Antarctica before the International Geophysical Year of 1957–58 was of a purely reconnaissance nature. Exploration during the IGY and post-IGY periods penetrated many hitherto unknown parts of the interior of East and West Antarctica and yielded a great deal of new and valuable information; but, even so, much of the continent is still unexplored and there are many problems, stratigraphical, structural and tectonic, that remain to be solved. With the passing of each year more and more geological information is brought to light, and it is being systematically fitted into the overall geological map of the continent. Although increased field work and new data have contributed to the solution of some problems, more problems have inevitably arisen as a result.

The state of Antarctic geology is certainly not static but mobile and advancing year by year. Therefore, at the present time it is opportune to review progress not specifically with a view to presenting a complete and dogmatic statement but to establish some reasonable basis of fact and interpretation upon which future workers in this fascinating field can build.

In the recent past several authors have attempted reviews of the geology of Antarctica but here, mainly because of the lack of space, only the broader aspects of stratigraphical correlation, structure and tectonics are discussed. Wherever possible, information has been set out in tabular form so that it can be used more readily and correlations can be more easily appreciated.

The southern continents—Antarctica is but one of the southern continents and, as such, its stratigraphical succession is likely to be similar to that of the other southern continents, which have been adequately reviewed by *King* [1958]. It is clear from King's work that he envisages a southern super-continent of Gondwanaland which disrupted into the present southern continental fragments in the early Cretaceous. To familiarize the reader with southern stratigraphy and elucidate King's hypothesis, Table 1 gives an adequate résumé to enable satisfactory discussion in the later sections of the present paper.

East Antarctica—For the present purpose it is convenient to subdivide Antarctica into *two* major geographical regions: East Antarctica, the larger part of the continent which lies to the east of a line joining the Weddell and Ross Seas, and including the south pole itself and the Pole of Inaccessibility; West Antarctica, the smaller part of the continent, lying in the western hemisphere and containing the Antarctic Peninsula and the Antarctandean Mountain chain.

To review the stratigraphy of East Antarctica six selected type areas (Fig. 1), where the succession is well known, are considered and these are compared in Table 2. A cursory glance at this table shows that the geological record in East Antarctica is particularly poor in post-Lower Jurassic times, but in the Upper Paleozoic and early Mesozoic there is a wealth of useful stratigraphical information.

The primitive crystalline continental shield of East Antarctica is represented by the Basement Complex (Fig. 2), comprising schists, gneisses and a variety of metamorphic rocks which invariably show at least two (and perhaps three) phases of regional metamorphism. The lower part of the Paleozoic, best known from the South Victoria Land, Oates Coast, and Theron Mountains areas, is again represented by sediments, which have suffered cataclastic metamorphism, and intrusives. Perhaps the most interesting of these older rocks are the *Archaeocyathus* limestones of undoubted Lower Cambrian age (Fig. 2), which have been found so far only as erratic blocks in the South Victoria Land and Theron Mountains areas. The Lower Devonian Horlick Formation of the Buckeye Range which abounds with marine brachiopods can perhaps be correlated in time with the plant-bearing sediments of South Victoria Land (Table 2). Clearly, at this time parts of the continent underwent a marine transgression prior to the climatic deterioration which ultimately led to the Permo-Carboniferous glaciation (Fig. 3). Long-sought and conclusive evidence of tillites has at last been described by *Long* [1962] from the Buckeye Range, but it must be borne in mind that *Reece* [1958] also described boulder conglomerates from Dronning Maud Land which could also be interpreted as tillites. It seems that Antarctica probably occupied the center from which the Permo-Carboniferous 'Antarctic Ice Sheet' flowed outwards to inundate its neighboring continents

TABLE 1—*Stratigraphical comparison of South Africa, the Falkland Islands, Brazil, Uruguay, and Argentina*

	South Africa	Falkland Islands (after *Adie* [1952])	Brazil, Uruguay, and Argentina
(?) Rhaetic to L. Jurassic	Karroo Dolerites Drakensberg Volcanics	Dolerite dykes 〰〰〰	Serra Geral Eruptives Botucatú Sandstone
U. Triassic	Cave Sandstone Red Beds Molteno Beds U. Beaufort Series	West Lafonian Beds	
L-M. Triassic	M. Beaufort Series L. Beaufort Series	Bay of Harbours Beds	Rio do Rasto Beds Upper Estrada Nova Beds
U. Permian	U. Ecca Series	Choiseul Sound and Brenton Loch Beds	〰〰〰 (?)
L. Permian	M. Ecca Series (*coal measures*)	Lafonian Sandstone	Lower Estrada Nova Beds
Lowest Permian	L. Ecca Series U. Dwyka Shales	Black Rock Slates	Iratý Shales Rio Bonito Beds
Permo-Carboniferous U. Carboniferous	Dwyka Tillite (*glacial*) L. Dwyka Shales 〰〰〰	Lafonian Tillite (*glacial*) Bluff Cove (Fitzroy Basin) Beds 〰〰〰	Itararé Beds (*glacial*) 〰〰〰
L. Carboniferous M. Devonian	Witteberg Series U. Bokkeveld Series (terrestrial sediments)	Port Stanley Beds Port Philomel Beds (terrestrial sediments)	Barreiro sandstone (Brazil)
L. Devonian	L. Bokkeveld Series Table Mountain Series (marine sediments) 〰〰〰	Fox Bay Beds Port Stephens Beds (marine sediments) 〰〰〰	Ponta Grossa (Brazil) Rincon de Alonsa (Uruguay) Furnas Sandstone (Brazil) Carmen Sandstone (Uruguay) Sierra de la Ventana Quartzites (Argentina) 〰〰〰
Precambrian	Basement Complex	Cape Meredith Complex	Basement Complex

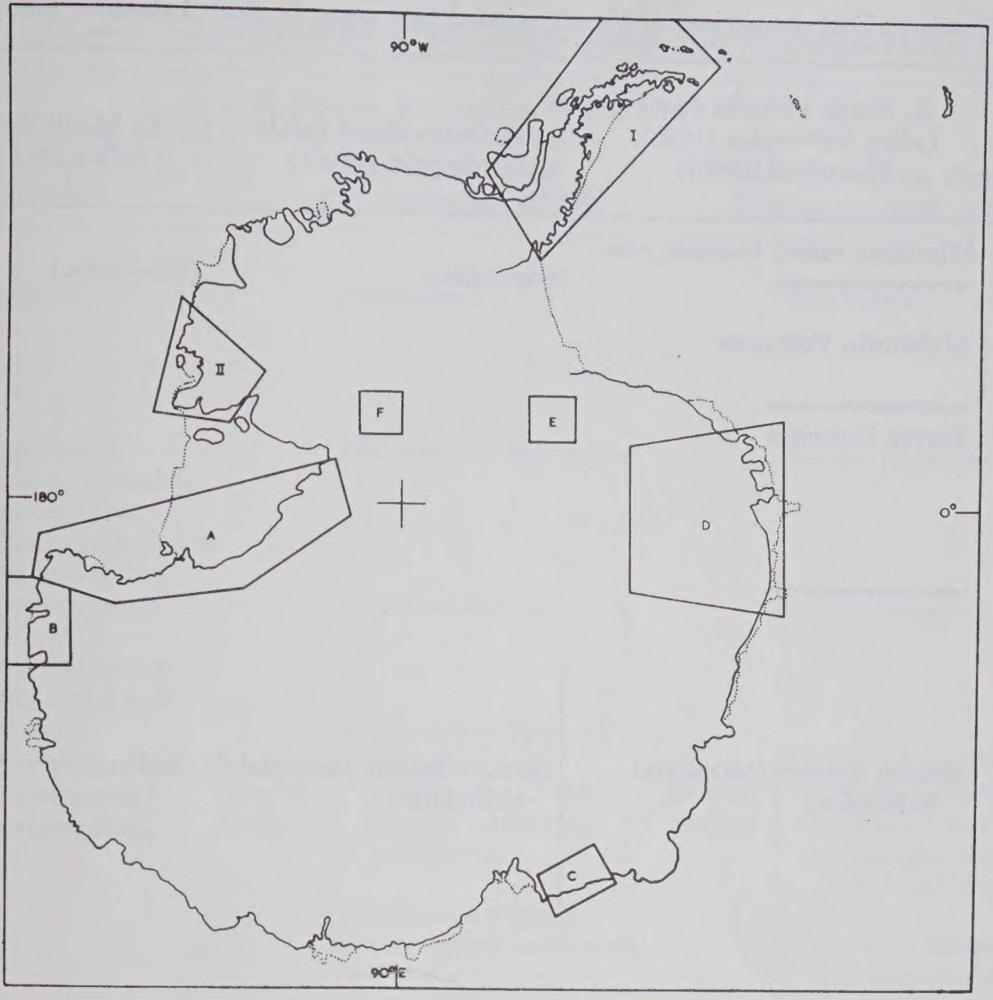

FIG. 1—Sketch map of Antarctica showing the type areas discussed; *East Antarctica:* A, South Victoria Land; B, Oates Coast; C, MacRobertson Coast; D, Dronning Maud Land; E, Theron Mountains, Whichaway Nunataks, and Shackleton Range; F, Central Horlick Mountains; *West Antarctica:* I, Antarctic Peninsula; II, Edsel Ford Ranges and King Edward VII Peninsula

and leave its mark in the form of the widespread tillites of South America, South Africa, India, and Australia.

With the climatic amelioration in Lower Permian times a large inland basin of sedimentation (similar to the Karroo Basin of South Africa) developed (Fig. 4). Under a temperate climate subaerial stripping of the surrounding landmasses became increasingly more active; the flora began to thrive and by Upper Permian times gave rise to the widespread coalfield of East Antarctica. This epoch of terrestrial sedimentation continued well into the Triassic, as the climate became more arid; near the top of the Beacon System desert conditions are apparent from the nature of the sediments. This phase of East Antarctic history was brought to a catastrophic close in the Lower Jurassic by the lava outpourings from the volcanoes of Dronning Maud Land and on the fringes of the sedimentary basin, while the sediments of the Beacon System, including the coal seams and plant-bearing beds, were injected both by sills and dykes of the Ferrar Dolerites.

At this stage the history of East Antarctica is broken, and the Cretaceous and Tertiary sediments, which are so well known from the other southern continents and the Antarctic Peninsula, are absent. The anti-climax of the geological record is the rejuvenation of late Tertiary volcanism (Fig. 5) and the onset of the Pleistocene glaciation of the continent. But what of the distant future of East Antarctica, when there could possibly be a reversal of climate such as that following the Permo-Carboniferous glaciation? The excellent geophysical work of the American and Russian teams has shown that much of East Antarctica would still be above

TABLE 2—*Stratigraphical comparison of the six selected type areas in East Antarctica shown in Fig. 1.*

	A, South Victoria Land (after *Harrington* [1958]; *Plumstead* [1960])	B, Oates Coast (after *Soloviev* [1960])	C, MacRobertson Coast (after *McLeod* [1960])
Quaternary	Moraines, raised beaches, etc. 〰〰〰	(*Glaciation*)	(*Glaciation*)
Tertiary	McMurdo Volcanics 〰〰〰		
L. Jurassic	Ferrar Dolerites		
Rhaetic	〰〰〰		
Triassic U. Permian L. Permian	Beacon System (terrestrial sediments)	Beacon System (terrestrial sediments)	Sediments with coal seams (terrestrial sediments) (*coal measures*)
Permo-Carboniferous	〰〰〰		
L. Devonian	Sediments with plant remains (terrestrial sediments?)	〰〰〰	
U. Silurian		Schist-greywacke Series (405×10^6 yr) 〰〰〰	
U. Cambrian	〰〰〰	Berg Series (500×10^6 yr)	
L. Cambrian	*Archaeocyathus* Limestones (known only from erratics)		
Lower Paleozoic	〰〰〰 Admiralty Intrusions		
Precambrian	〰〰〰 Ross System (Moubray Group)	〰〰〰 Basement Complex	〰〰〰 Basement Complex (2 episodes of metamorphism)

Table 2—*Stratigraphical comparison of the six selected type areas in East Antarctica shown in Fig. 1.* (*Cont'd.*)

D, Western Dronning Maud Land (after *Roots* [1953]; *Reece* [1958])	E, Theron Mountains, Whichaway Nunataks, and Shackleton Range (after *Stephenson* [1960])	F, Buckeye Range, Central Horlick Mountains (after *Long* [1962])
(*Glaciation*)	(*Glaciation*)	(*Glaciation*)
Basalt dykes Andesitic volcanics (pillow lavas) Gabbroic and dioritic sills and dykes	Dolerite sills and dykes	Ferrar Dolerites (diabase)
〰〰〰	〰〰〰	〰〰〰
Beacon System: Clastic sediments (terrestrial sediments) ? Tillite (*glacial*)	Beacon System: Sediments with plant remains (*coal measures*) and coal seams (terrestrial sediments) Sedimentary group (terrestrial sediments)	Beacon System: Mount Glossopteris Formation (terrestrial sediments) (*coal measures*) (arkoses, sandstones and shales with plants and woods)
		Discovery Ridge Formation (carbonaceous shale, cone-in-cone limestone, platy shale) 〰〰〰 Buckeye Tillite (*glacial*) (with intercalated sandstones) 〰〰〰 Horlick Formation (marine sediments) (sandstone-shale with marine fossils)
	〰〰〰	
	Slate-quartzite Group	
	〰〰〰	
	Archaeocyathus limestones (known only from erratics)	
	〰〰〰	〰〰〰
Metamorphic complex	Basement Complex	Basement (porphyritic biotite-quartz-monzonite)

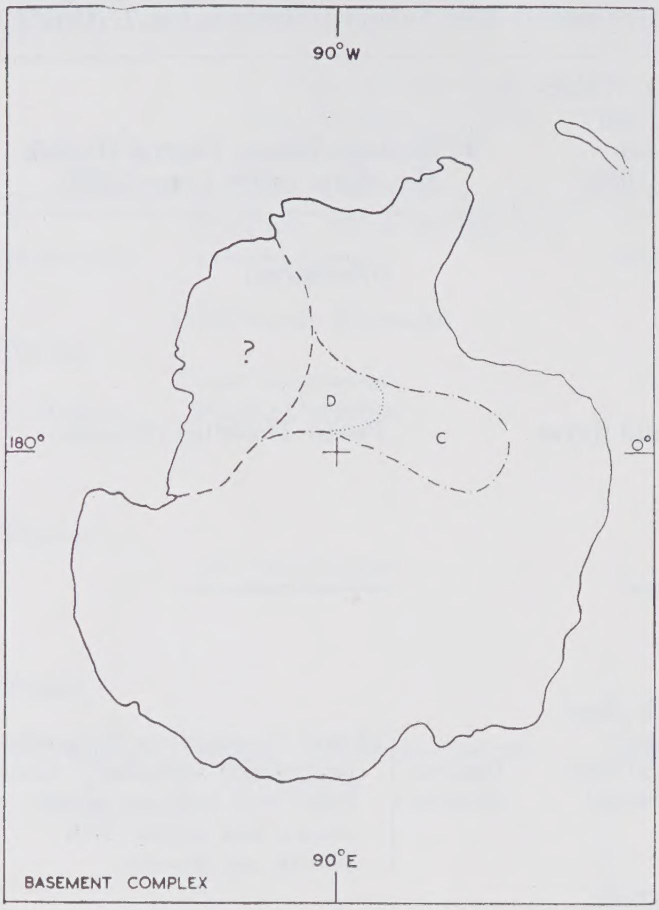

Fig. 2—The primitive Antarctic crystalline shield of Precambrian times, and superposed: C, the extent of the marine transgression of the Lower Cambrian; D, the withdrawal of the sea during the Lower Devonian

sea-level after deglaciation (Fig. 6) and taking isostatic compensation into account.

West Antarctica—Although recent work in the Ellsworth Highland and Marie Byrd Land areas has contributed much to the knowledge of West Antarctica and confirmed many ideas on the geology of these regions, it is convenient to discuss here in the first place the well-known Antarctic Peninsula and King Edward VII Peninsula areas (Fig. 1). In Table 3 the stratigraphic successions of these areas are compared with that of the west Patagonian Cordillera of South America.

The stratigraphy of the Antarctic Peninsula has already been discussed generally by *Adie* [1953, 1960] and he has also described in detail the more important stratigraphic units which have contributed to the building of the peninsula [*Adie,* 1953, 1954, 1955, 1957]. However, in order to place West Antarctica in its correct relationship to East Antarctica and enable further discussion it is necessary to review briefly the geological history of this area.

The basement crystalline shield of Antarctica is not entirely confined to East Antarctica but it extends into parts of West Antarctica (Fig. 2), especially into the southern Antarctic Peninsula; so far, the Basement Complex (exhibiting at least two phases of regional metamorphism) is only known south of the Marguerite Bay area. Early Paleozoic volcanic and intrusive rocks, probably of Cambrian age, also occur in the latter area in association with the Basement Complex. There is no evidence of Ordovician-Devonian rocks in West Antarctica and it can only be presumed that this was a period when erosion was supplying material from the highlands to the areas invaded by the Cambrian and Lower Devonian seas (Fig. 2).

The Carboniferous is characterized by the subsidence of the great Andean geosyncline

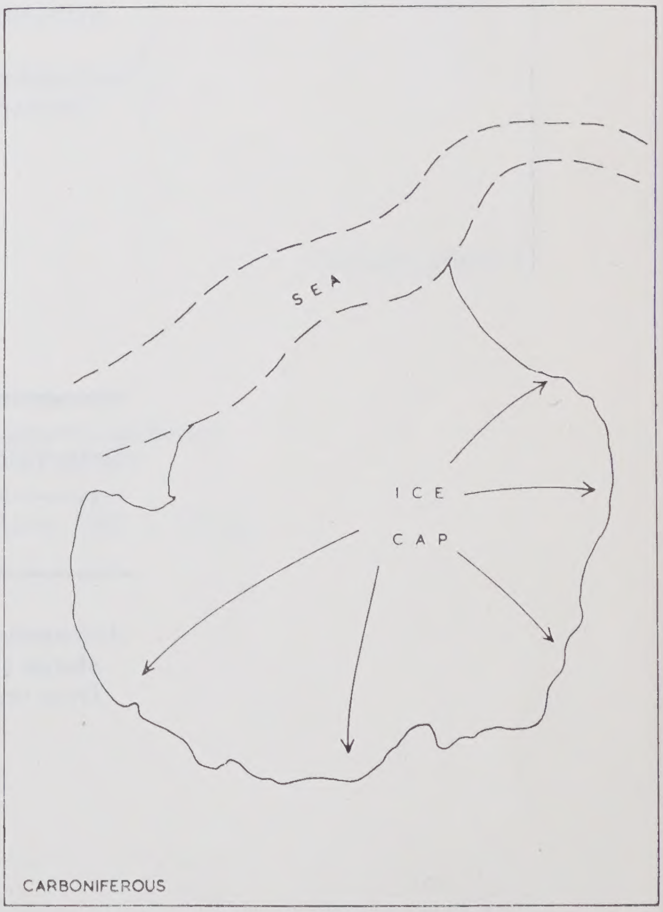

Fig. 3—The state of Antarctica in the Carboniferous and Permian, showing the development of the Carboniferous (Andean) geosyncline (which ultimately gave rise to the Trinity Peninsula Series of the Antarctic Peninsula) and the Permo-Carboniferous ice sheet with its center over Antarctica

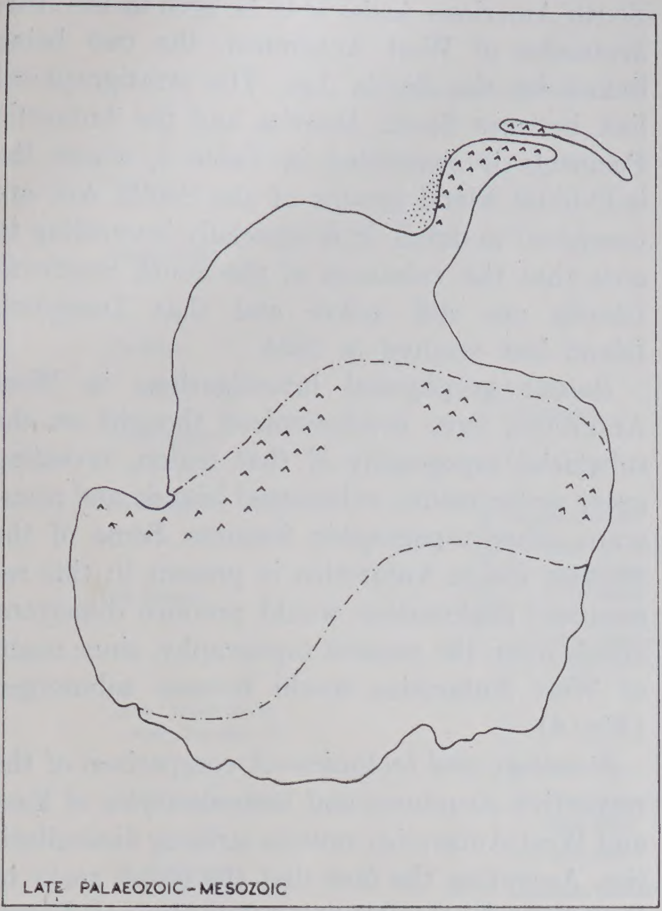

FIG. 4—The state of Antarctica in the late Paleozoic and early Mesozoic showing the extent of the depositional basin that gave rise to the Beacon System, and the Lower Jurassic volcanism in East Antarctica. In the Upper Jurassic extensive andesite-rhyolite eruptions occurred in the Antarctic Peninsula and South Shetland Islands, while in Alexander Island ashes were deposited in the sea offshore

(Fig. 3) (which formed alongside the stable block of East Antarctica) and intensive deposition, which subsequently gave rise to the greywacke facies sediments of the widespread Trinity Peninsula Series. Fairly certainly, the activity of the Andean geosyncline had drawn to a close before the onset of the Permo-Carboniferous glaciation, otherwise traces of glacial debris would surely have been found in the sediments of the Trinity Peninsula Series and its equivalent in the Sentinel Mountains and northern Marie Byrd Land.

Climatic amelioration in the Antarctic Peninsula, accompanied by luxuriant plant growth, is clear from the remarkable Middle Jurassic succession of the Hope Bay area, where lacustrine deposits contain well-preserved ferns associated with fresh-water gastropods, fish-remains, and aquatic beetles. As was the case in East Antarctica, these conditions were sharply truncated by the onset of volcanism, with the almost complete destruction of the vegetation by tuffaceous eruptions over a wide area (Fig. 4). Some of these ashes were deposited in the sea near Alexander Island, exterminating belemnites and incorporating them as a permanent stratigraphic record.

The rejuvenation of the Carboniferous Andean geosyncline adjacent to its earlier position began in the Aptian, as the observations from Alexander Island well show, but it did not attain its full maximum until the Upper Cretaceous (L.-M. Campanian). In the northern part of the Antarctic Peninsula the Lower to Middle Campanian marine succession compares remarkably well with that of Tierra del Fuego (the Magellan geosyncline).

It was not until the late Cretaceous-early Tertiary that West Antarctica, especially the Antarctic Peninsula, achieved much of its pres-

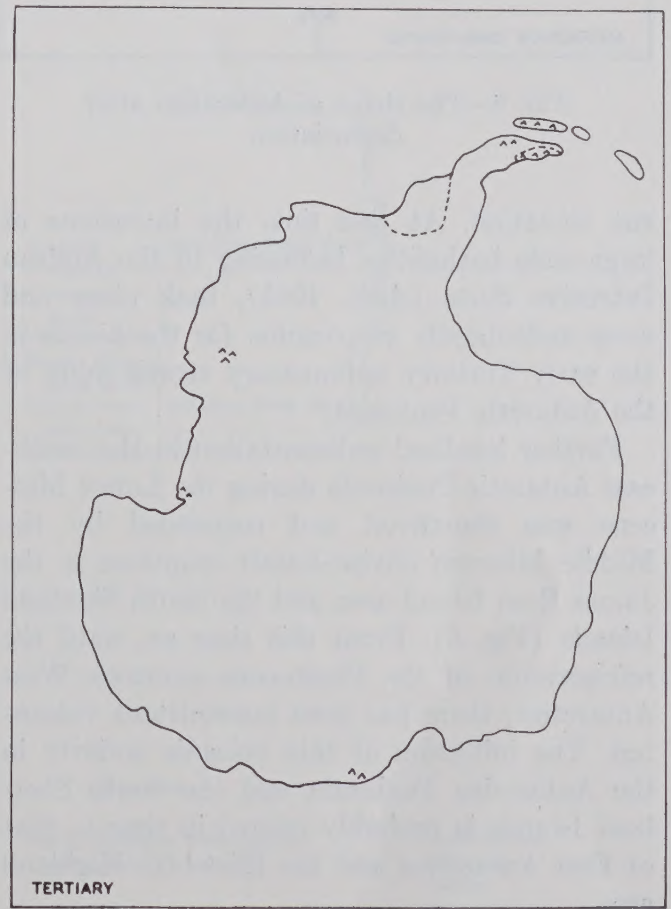

FIG. 5—The configuration of Antarctica in the late Tertiary, when the volcanoes of East Antarctica and Marie Byrd Land were commencing eruption and there was intense volcanic activity in the northeast Antarctic Peninsula and the South Shetland Islands

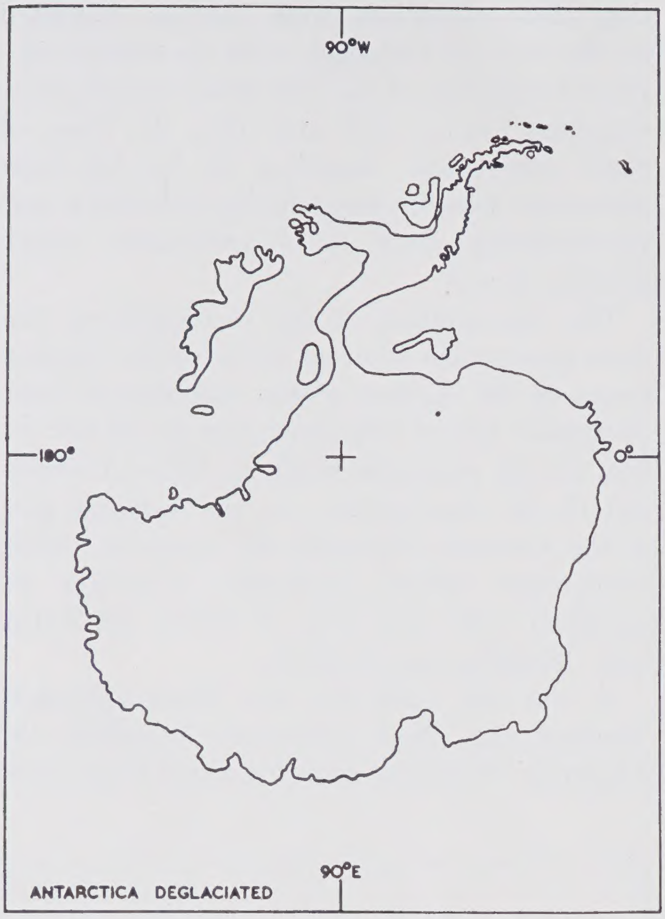

FIG. 6—The shape of Antarctica after deglaciation

ent elevation. At this time the intrusions of large-scale batholiths, belonging to the Andean Intrusive Suite [*Adie,* 1955], took place and were undoubtedly responsible for the hiatus in the early Tertiary sedimentary stratigraphy of the Antarctic Peninsula.

Further localized sedimentation in the northeast Antarctic Peninsula during the Lower Miocene was shortlived and suspended by the Middle Miocene olivine-basalt eruptions in the James Ross Island area and the South Shetland Islands (Fig. 5). From this time on, until the refrigeration of the Pleistocene overtook West Antarctica, there has been intermittent volcanism. The initiation of this volcanic activity in the Antarctica Peninsula and the South Shetland Islands is probably related in time to that of East Antarctica and the Ellsworth Highland area.

A close examination of Table 3 indicates there is a strong similarity between the respective geological histories of the west Patagonian Cordillera and West Antarctica. Indeed this is to be expected, since the mirror image of the South American Andes is to be seen in the Antarctandes of West Antarctica, the two being linked by the Scotia Arc. The stratigraphical link between South America and the Antarctic Peninsula is completed in Table 4, where the individual island groups of the Scotia Arc are compared in detail. It is especially interesting to note that the volcanoes of the South Sandwich Islands are still active and that Deception Island last erupted in 1834.

Recent geophysical investigations in West Antarctica have revolutionized thought on the subglacial topography of that region, revealing great embayments, submerged islands and numerous other topographic features. Some of the thickest ice in Antarctica is present in this region and deglaciation would produce disastrous effects upon the present topography, since much of West Antarctica would become submerged (Fig. 6).

Structure and tectonics—A comparison of the respective structures and tectonic styles of East and West Antarctica reveals striking dissimilarities. Accepting the fact that the oldest rocks of the continent, the Basement Complex and Lower Paleozoic, have suffered the same or a similar regional metamorphic history, it is immediately apparent that the tectonics of East Antarctica are relatively simple and are those associated with a stable continental platform. The ubiquitous late Paleozoic-Mesozoic Beacon System is invariably near-horizontal and this is frequently emphasized by the Ferrar Dolerite intrusions. As far as can be seen, the only recorded tectonic history is one of meridional faulting, which was probably of late Tertiary age and with which the late volcanic eruptions were associated.

In strong contrast West Antarctica has suffered a more varied tectonic history, which is associated with the emergence of the Carboniferous Andean geosynclinal sediments in near pre-Jurassic times. The Trinity Peninsula Series and its correlatives in West Antarctica were severely folded and even overfolded in acute contortions by a major orogeny related to the formation of the 'primitive' Scotia Arc. With the emplacement of the Andean Intrusive Suite further mild folding occurred in the late Cretaceous—early Tertiary. Without doubt, this was accompanied by block faulting which has in part been responsible for much of the present topographic elevation of West Antarctica and

TABLE 3—*Stratigraphical comparison of the Patagonian Cordillera and two type areas in West Antarctica shown in Fig. 1*

	Patagonian Cordillera		I, Antarctic Peninsula (after *Adie* [1953])		II, Edsel Ford Ranges and King Edward VII Peninsula (after *Warner* [1945]; *Wade* [1945]; *Passel* [1945])
	Andean Geosyncline	Magellan Geosyncline		Alexander Island	
Recent			Sea-level changes		
(Pleistocene)			(*Glaciation*) 〰	Volcanic rocks of South Shetland Islands (Deception Island), Osterrieth Range volcanics and associated dykes	(*Glaciation*)
Pliocene			Pecten Conglomerate 〰		
M. Miocene		Volcanics	James Ross Island Volcanic Group 〰		Olivine-fourchite volcanics
L. Miocene		〰	Seymour Island Series		
M. Eocene		Sediments with coal seams (terrestrial sediments) Shales (marine sediments)	〰		〰
Late Cretaceous to early Tertiary (?)		〰	Andean Intrusive Suite (basic to acid) 〰		Intrusive suite (basic to acid)
L.-M. Campanian		Sediments (marine sediments) 〰	Snow Hill Island Series Cape Longing Series		
M. Cretaceous		Andean batholith intrusions			
Aptian	Sediments (marine sediments) 〰	〰		Fossil Bluff Series	
U. Jurassic	Red sandstones Andesitic volcanics	Série Porfírico (volcanics)	Andesite-rhyolite volcanic group 〰	Belemnite Point Beds	〰
M. Jurassic	〰		Mount Flora plant beds Church Point plant beds Basal conglomerate	Ablation Hook Beds	
Rhaetic U. Triassic	Sediments with plant remains (terrestrial sediments) Sediments (marine sediments) Tuffs with plant remains (terrestrial sediments) Acid volcanics Sediments (marine sediments) 〰				
Permo-Carboniferous	Slates, sandstones, limestones, conglomerates Tillite (?) (*glacial*) 〰 Slates, greywackes and quartzites with rare plant remains		〰		
Carboniferous (?)			Trinity Peninsula Series (marine sediments)		Metamorphosed sediments (marine sediments)
Devonian or L. Carboniferous	Phyllitic slates and sandstones with rare plant remains		〰 〰		
Early Paleozoic (?)	〰		Volcanics 〰 Intrusives		
Precambrian	Basement Complex		Basement Complex		

Table 4—*Stratigraphical comparison of the islands of the Scotia Arc*

	Shag Rocks (after *Tyrrell* [1945])	South Georgia (after *Trendall* [1953, 1959])	Clerke Rocks (after *Holtedahl* [1929])	South Sandwich Islands (after *Tyrrell* [1945])
Recent		Raised beaches		Andesite-dacite volcanic group (active volcanoes)
Pleistocene				
		(*Glaciation*)		
Pliocene				
Miocene		Basic dykes	Basic dykes	
Oligocene				
		〰〰〰	〰〰〰	
Eocene		Andean Intrusive Suite	Andean Intrusive Suite (granite)	
U. Cretaceous		〰〰〰 Dykes 〰〰〰		
L. Cretaceous		Interbedded sediments and spilites of Annenkov Island (marine sediments) and the south coast		
U. Jurassic				
M. Jurassic				
Triassic		Cumberland Bay Series (marine sediments)		
		〰〰〰	〰〰〰	
Carboniferous (?)	Greywackes	Sandebugten Series (marine sediments)	Greywackes (known only from erratics)	〰〰〰
Lower Paleozoic				? Dolomitic mudstones
	〰〰〰	〰〰〰		〰〰〰
Precambrian	? Schists	Basement Complex		? Schists

TABLE 4—*Stratigraphical comparison of the islands of the Scotia Arc (Cont'd)*

	South Shetland Islands			
South Orkney Islands (after *Matthews* and others [in press])	Elephant & Clarence Islands (after *Tilley* [1930]; *Tyrrell* [1945])	King George Island (after *Hawkes* [1961*a*])	Deception Island (after *Hawkes* [1961*b*])	Livingston Island (after *Hobbs* [1959])
Raised beaches Wave-cut platforms		Raised beaches	Post-Caldera Series: Whalers Bay Group Pendulum Cove Group Neptunes Bellows Group	Raised beaches Wave-cut platforms
∿∿∿∿∿		∿∿∿∿∿		
		Penguin Island Group		
(*Glaciation*)		(*Glaciation*)	∿∿∿∿∿	(*Glaciation*)
		Pecten Conglomerate	Pre-Caldera Series: Port Foster Group	
		∿∿∿∿∿		∿∿∿∿∿
		Point Hennequin Group		
		∿∿∿∿∿		
		Fildes Peninsula Group		Younger volcanic group
Conglomerates Shales		∿∿∿∿∿		∿∿∿∿∿
		Andean Intrusive Suite		Andean Intrusive Suite
∿∿∿∿∿		∿∿∿∿∿		∿∿∿∿∿
Dolerite dykes		Upper Jurassic Volcanic Group		Older volcanic Group: Renier Point lavas Mount Bowles agglomerate
∿∿∿∿∿				
Derived Series				
∿∿∿∿∿				∿∿∿∿∿
Greywacke-shale Series				Miers Point Series
∿∿∿∿∿	∿∿∿∿∿	∿∿∿∿∿		∿∿∿∿∿
Basement Complex: Moe Island Series Amphibolite Series Marble Series	Basement Complex: Phyllites ∿∿∿∿∿ Schists	Basement Complex		False Bay schists

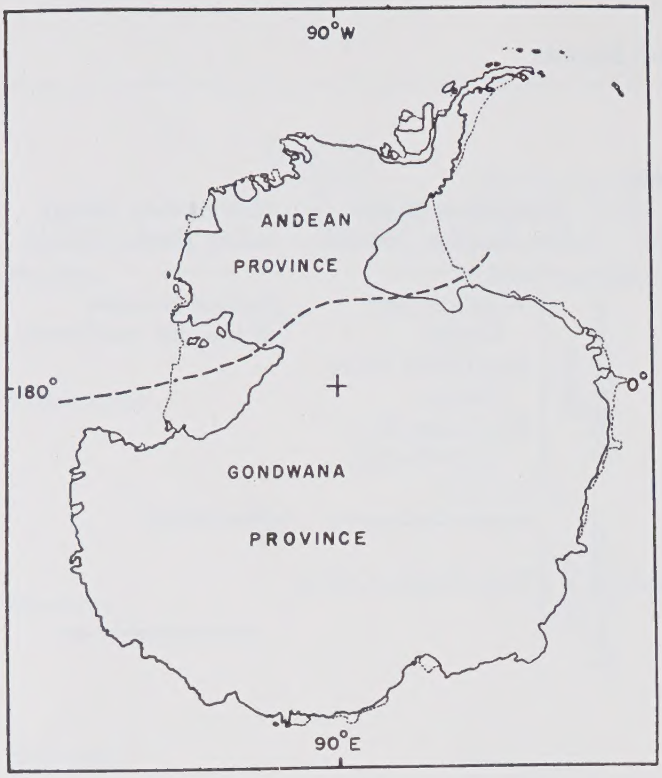

Fig. 7—The true geological sub-division of Antarctica into the Andean Province and the Gondwana Province

the plateau of the Antarctic Peninsula. It is also possible that in the late Tertiary rejuvenated faulting along earlier lines occurred, and with this was associated the onset of volcanism.

Discussion—From the abundance of information set out above it emerges that Antarctica is not only subdivided into *two geographical regions*. The more the geology of Antarctica is studied the more it becomes apparent that Antarctica is composed of *two geological provinces*, each of which has evolved independently but in adjacent positions in similar climatic environments. The geological history of the old stable platform of East Antarctica is closely similar to that of the other southern continents (see Tables 1 and 2), where the great Gondwana System dominates the stratigraphy, and for this reason the name 'Gondwana Province' (Fig. 7) is proposed for this geological unit. On the other hand, West Antarctica is essentially considerably younger than East Antarctica but it has a more complex tectonic history. West Antarctica is geologically closely akin to the South American Andes and is indeed its southerly continuation via the Scotia Arc. For this reason, therefore, the name 'Andean Province' (Fig. 7) is proposed for the geological unit comprising West Antarctica.

This is just the beginning of the geological investigation of Antarctica: there still remain multitudes of problems to be solved and many thousands of square miles of ice and snow to be covered in the search for new information that will eventually lead to the complete solution of Antarctic geology.

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